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ORIGINAL ARTICLE

The effect of resistance inspiratory muscle training in the management of breathlessness in patients with thoracic malignancies: a feasibility randomised trial

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Abstract
Objectives Breathlessness in patients with lung cancer is a common and distressing symptom affecting 50–70 % of patients, rising to some 90 % for those with advanced lung cancer. The aim of the current study was to assess how feasible inspiratory muscle training (IMT) is in the lung cancer population and explore changes in outcome variables.
Materials and methods A pilot feasibility randomised trial was conducted in patients with clinically stable lung cancer. The experimental group received training using a pressure threshold device. Patients were instructed to carry out five IMT sessions weekly for 12 weeks for a total of 30 mins/day. Patients in the control group received standard care. Outcome measures were completed at baseline and monthly for 3 months, and included: physiological parameters (FEV1, FVC); perceived severity of breathlessness using six 10-point NRS; modified Borg Scale; quality of life using the short form Chronic Respiratory Disease Questionnaire; Hospital Anxiety and Depression Scale, and safety.
Results Forty-six patients (M=37, F=9) at a mean age of 69.5 years old and a mean of 16 months post-diagnosis who were not currently receiving chemotherapy and/or radiotherapy were recruited. Seventy-percent had NSCLC and advanced disease. Statistical (area under the curve-AUC) and clinically important differences were seen with regard to distress from breathlessness (p=0.03), ability to cope with breathlessness (p=0.01), satisfaction with breathlessness management (p=0.001), fatigue (p=0.005), emotional function (p=0.011), breathlessness mastery (p=0.015) and depression (p=0.028). The m-Borg difference between the two groups at 3 months was 0.80, which is borderline clinically significant. Changes were more evident in the 3-month assessment where the effect of the intervention came to its peak.
Conclusion This trial shows the IMT is feasible and potentially effective in patients with lung cancer. These findings warrant a fully powered larger randomised controlled trial.

Keywords Inspiratory muscle training · Breathlessness · Dyspnoea · Lung cancer · Breathing exercise · Emotional functioning

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Introduction

About three-quarters of lung cancer (LC) patients experience dyspnoea at some time, and this rises to nearly 90 % in their last month of life [1]. Dyspnoea is more refractory to treatment than pain and less responsive to pharmacological interventions, often remaining poorly controlled [2]. Whatever the LC treatment, the growth of the cancer and invasion of lung tissues and surrounding tissues may interfere with breathing, leading to symptoms such as shortness of breath or dyspnoea.

Inspiratory muscle training (IMT) has been used since the 1980s as a non-pharmacological intervention for respiratory symptoms [3]. The purpose of IMT is to improve inspiratory

muscle strength and endurance by having an effect on respiratory symptoms, exercise capacity and health-related quality of life [3]. IMT can strengthen the inspiratory muscles, and stronger inspiratory muscles require less effort during a given task, hence dyspnoea is reduced [4]. Controlled breathing can improve dyspnoea too [5], and IMT is one such method. In patients with chronic obstructive pulmonary disease (COPD), controlled breathing works to relieve dyspnoea by reducing dynamic hyperinflation of the rib cage and improving gas exchange, increasing strength and endurance of the respiratory muscles, and optimising the pattern of thoraco-abdominal motion [6]. Other authors showed that IMT can cause structural changes in inspiratory muscle fibres [7]. Improving inspiratory muscle strength and endurance is one management strategy that may help to relieve the symptoms of dyspnoea, thereby increasing the level of activity and improving the quality of life for patients with respiratory problems.

A systematic review reported the results of thirteen trials to determine the effect of IMT on inspiratory muscle strength and endurance, exercise capacity, dyspnoea and quality of life for adults with COPD. Results indicated that targeted or threshold IMT was associated with significant improvements in some outcomes of inspiratory muscle strength (PImax) and endurance (inspiratory threshold loading), exercise capacity, work rate maximum and dyspnoea [8]. Similar results were suggested by another systematic review, which was based on 16 trials on adults with COPD [9]. Our own systematic review more recently has added more information in the field and showed that IMT can be a potentially useful intervention for managing dyspnoea in non-cancer chronic respiratory diseases [5].

However, no evidence is available for the effects of IMT on LC patients. Given that COPD and lung cancer are related [10], it is possible that IMT is effective on patients suffering with LC. Several authors have concluded that it is unclear to what extent the COPD disease process may contribute to lung cancer risk, or whether both COPD and lung cancer are a consequence of the underlying exposure, or perhaps a combination of both [11, 12]. In addition to this, most lung cancer patients will also have COPD [13, 14], because both conditions are mainly caused by smoking [15]. As a consequence, many of the symptoms of LC are similar to those with COPD. For example, patients with COPD and cancer experience increased resistance to airflow, air trapping and hyperventilation of the lung, which places the inspiratory muscles at a mechanical disadvantage. The breathing is diminished, and the respiratory rate becomes more rapid [16]. Functionally, this presents as dyspnoea and decreased exercise tolerance in individuals with COPD [8]. In response, patients may self limit their activities of daily living, resulting in a further increase in their sensation of dyspnoea and reduction in their exercise tolerance and quality of life [3]. Improving the inspiratory muscle strength and endurance is a strategy that can be meaningful to patients with respiratory problems and a diagnosis of LC.

Hence, the aim of the study was to assess the feasibility and effectiveness of inspiratory muscle training in patients with thoracic malignancies regarding their dyspnoea, psychological distress and quality of life.

Methods

Design

The trial is a two-arm, non-blinded, randomised controlled, proof-of-principle study. Patients were randomly assigned through a computer programme to IMT or a control group. The IMT group received standard care (which may have included specialist nursing input, opioids or oxygen and use of primary care services), and additionally included the intervention with home follow-up every month for 3 months. The control group also received standard treatment in a fast-track design [17], completed the same outcome measures as the training group, was visited at home as in the experimental group for assessments and received the intervention if they wished so after the end of their participation to the trial. Hence, frequency and type of contact between the two groups were the same.

The sample included a heterogeneous group of 46 outpatients cared for in two large cancer centres in the UK and one in Cyprus. Inclusion criteria were a) adults with histological diagnosis of primary LC or mesothelioma; b) refractory dyspnoea not responding to current treatment for the past 2 weeks (breathlessness daily for 3 months at rest or on minimal exertion where contributing causes have been treated maximally); c) expected prognosis of >3 months as judged by the clinicians and d) oxygen saturation above 85 % at rest.

Those with unstable COPD with frequent or acute exacerbations, rapidly worsening dyspnoea requiring urgent medical intervention, treatment with palliative radiotherapy to the chest received within 4 weeks or chemotherapy within 2 weeks, experiencing intractable cough, and those having unstable angina or clinically significant pleural effusion needing drainage were excluded. Use of steroids and opioids was allowed as 45–73 % and 45–64 % of patients respectively may use them [2]; such use along supplemental oxygen use was fairly balanced between the two groups, and data for these three variables was collected throughout the study to assess any major imbalances. Patients of any smoking status were included.

Intervention

A pressure threshold device was used to deliver IMT, which is commercially available by Phillips Respironics (Fig. 1). It includes a mouthpiece and calibrated spring-loaded valve,

Fig. 1 Photograph of a threshold inspiratory muscle trainer device

which controls a constant inspiratory pressure training load that is maintained unless the patient drastically alters his/her breathing pattern. A flow-independent one-way valve in the IMT device ensures consistent resistance, and the device features an adjustable specific pressure setting (in cm H_2O) to be set by a healthcare professional. When patients inhale through the IMT device, the valve blocks air flow until the patient generates sufficient inspiratory pressure to overcome the resistance provided by the spring-loaded valve. The patient must generate the inspiratory pressure, in order for the valve to open and allow inhalation of air. The valve is calibrated and can be adjusted according to a percentage of the patient's maximum inspiratory pressure (PImax in cmH_2O) [3]. PImax measures the maximal inspiratory mouth pressure against an occluded airway, which is a common evaluation method of inspiratory muscle strength and is expressed in cmH_2O. The pressure settings are adjustable in $-2cmH_2O$ increments (range, $-7cmH_2O$ to -41 cmH_2O). Threshold trainers (devices) provide a constant pressure (regardless the patient's airflow), which eliminates the need for a pressure indicator.

As no previous work has taken place in a LC population, we have followed standard practices reported in the COPD literature and guidelines from the company that distributes IMTs. Previous work on this area suggests that the IMT protocol should follow five sessions weekly for 12 weeks for 30 mins/day, divided over two sessions [3]. However, sessions initially needed to be as short as 3–5 mins if patients had difficulty completing the whole session due to tiredness or breathlessness. Two of these sessions took place under supervision in hospital over the same day for the purpose of monitoring attained mouth pressure and IMT technique. The duration of inspiration was 1.5 to 2 s and the duration of expiration 6 s. The respiratory rate therefore was approximately 8 breaths/min. Exercise intensity for training of the inspiratory muscles was set according to the PImax. As it is recommended by Reid et al. [18], the initial training intensity may be as low as 40 % PImax. Besides reducing the risk of fatigue or injury, the advantage of using a low starting intensity is that initial training will be better tolerated and can be progressed more quickly, thus improving patient satisfaction and adherence. The percentage of PImax can be progressed as tolerated up to 5 % per week to a maximum, of 70 % PImax.

Procedures

The study received approval from a Research Ethics Committee and the hospitals involved in both countries. Patients were recruited at the outpatients' clinics of the participating hospitals or identified by the clinicians and referred to the research team. Those who agreed to participate and provided signed consent completed all baseline measurements and returned them to the researchers before randomisation. All patients were invited to attend the research clinics at each study site for spirometry assessment. Patients allocated to experimental group further had training in the use of the IMT, and the trainer (device) was adjusted to a level which was comfortable to each patient. Home visits were conducted monthly in the IMT group for the duration of the trial for spirometry assessment and for adjusting the IMT's resistance level upwards. Consistency in the research process, assessments and delivery of education was maintained using a detailed protocol to each site, regular supervision of the research assistants and discussion of the process in the investigators' regular meetings.

Outcome measures

All assessments were carried out at baseline and weeks 4 (T1), 8 (T2) and 12 (T3). As this is a feasibility trial, no primary outcome was pre-set. It took patients 10–20 min to complete them, and there was no missing data in any item. All scales were completed by the patients themselves.

Physiological data was collected through spirometry assessment (FVC, FEV1, FEV1% and PEF).

Perceived severity of breathlessness (average and 'worst' over the past 24 h, and "now") and distress caused by breathlessness was measured on a 0–10 Numerical Rating Scale (NRS) [19, 20], anchored as follows: 0=no breathlessness/no distress due to the breathlessness and 10=worst imaginable breathlessness/distress due to breathlessness. In the same mode, patients' ability to cope with breathlessness and satisfaction with the management of their breathlessness were also assessed.

The modified Borg Scale is a vertical scale labeled 0–10, with corresponding verbal expressions of progressively increased intensity from "nothing at all" to ''maximal."

The Chronic Respiratory Disease Questionnaire-short form (CRDQ) was used [21]. This is an 8-item scale which has been developed from the original 20-item version [22] for the assessment of quality of life in patients with chronic airflow limitations. It covers four aspects of the patient's life: dyspnoea, fatigue, emotional function and mastery (the feeling of control over the disease and its effect). It is one of the few instruments that focuses on breathlessness from the patient's point of view and on its impact on quality of life. This focus on breathlessness-related quality of life, its strong psychometric properties in COPD samples and its ease of use were the criteria for selecting this scale for our study, as there is no other similar validated scale in the LC population. This pilot study could provide evidence of its validity for future use in a larger trial with LC patients.

Hospital Anxiety and Depression Scale (HADS) [23]. This is a 14-item well-established scale measuring anxiety and depression, commonly used and validated in cancer patients [24].

Essential precautions were considered when prescribing IMT to avoid or minimise overtraining and prevent hypercapnea. Signs of inspiratory muscle fatigue/weakness or hypercapnea were monitored either through self-report or by asking patients during their clinic visit. If any of these signs appeared, patients were advised to delay their sessions until all signs and symptoms subsided.

To assess patient compliance, each patient in the experimental arm was given a training diary to record IMT home practice sessions.

Data analysis

The statistical software package IBM SPSS version 19.0 was used. Descriptive statistics were used to summarise the sample characteristics. Non-parametric tests were used because of the small sample size in this pilot study. NRS scores were analysed using three approaches: 1) the NRS score differences between intervention and control groups at each time point (baseline-to-T1/T2/T3) were examined using Mann-Whitney U test; 2) the area of the NRS curves was calculated, and their difference between IMT and non-IMT groups was compared using Mann-Whitney *U* test and 3) the differences between NRS scores at two different time points within the same group were compared using Wilcoxon Sign-ranked test. The effect of time on the outcome measurements within the group was examined using Friedman tests. Cronbach alpha reliability was calculated for the CRDQ, as this scale has not been used previously in a LC population. In accord with good statistical practices for randomised controlled trials, the two groups were not compared statistically at baseline. A p value of <0.05 was considered statistically significant. No ITT analysis was carried out, as we excluded two patients from analysis who did not met eligibility criteria (did not have breathlessness), but due to an administrative error, they were inappropriately randomised to the trial arms.

Results

Sociodemographic and clinical characteristics

Forty-six patients participated (CONSORT Diagram 1). Twenty-five were recruited from UK centre A, 2 from UK centre B and 19 from the Cyprus centre. Patients were at a mean age of 69.5 years (range=51–85, SD=8.35) and a mean of 16 months post-diagnosis (range=1–91, SD=18). Most had non-small cell LC and were at an advanced stage of the disease (Table 1). Completion of all scales was good, and only those dropping out did not complete the questionnaires. More specifically, 91 % of patients completed the scales at T1, 85 % at T2 and 81 % at T3.

IMT resistance and use

From an initial mean starting level of 15 cmH_2O, the mean IMT resistance level at T1 was 18 (SD=6.4), T2 was 23 (SD=9.4) and T3 was 26.5 (SD=11) cmH_2O. Frequency of use was 68–80 times per month, with a decline at T3. Duration of use was 300–335 min each month.

Spirometry

Both time and its interaction with the intervention (IMT/No-IMT) had no significant effect on PEF, FVC and FEV-1. Table 2 shows detailed spirometry data.

Dyspnoea parameters

mBorg Scale

There was no significant difference in the mBorg score within the IMT group. However, significant difference (p=0.033) was found within the no-IMT group, with its mBorg score

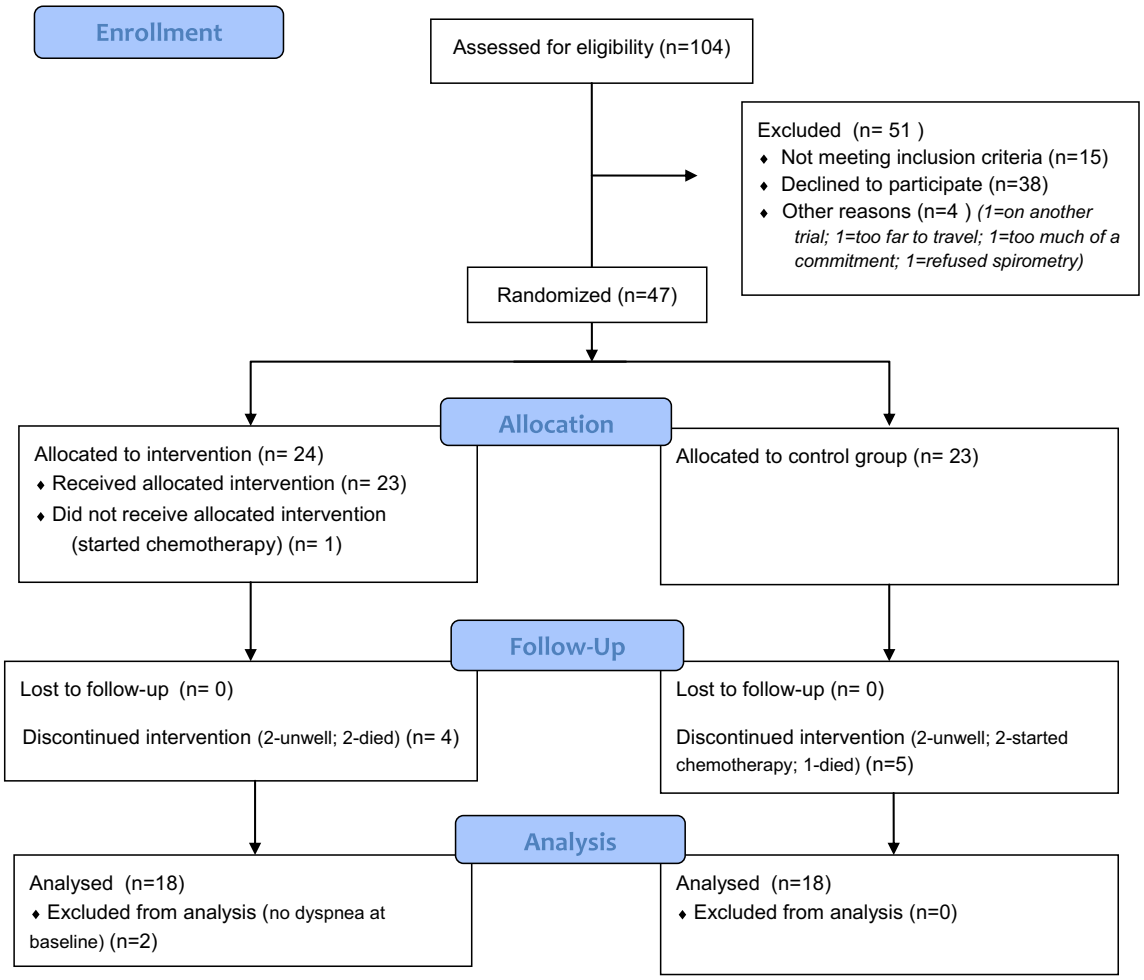

Diagram 1 CONSORT diagram of patient flow in the trial

(3.4±1.4) at T_2 being significantly (p=0.013) higher (worse) than the score at baseline (2.7±1.4). Comparing the scores at each time point between the two groups, it was shown that the mBorg score of the no-IMT group was significantly higher (p=0.029) than the IMT group (2.5±1.0) at T_2 (Fig. 2).

Worst breathlessness over the past 24 h

Among the IMT group, significant difference (p=0.038) was found between T_1 (6.2±1.2) and T_2 (5.1±2.0). However, the score for worst breathlessness at baseline (5.9±2.2) was significantly lower than T_1 (6.7±2.2) and T_3 (7.0±1.9) in the no-IMT group, suggesting worsening breathlessness. For two independent group comparisons, the no-IMT group's worst breathlessness was significantly (p=0.003) higher than the IMT group at T_3 (Fig. 3a).

Average breathlessness over the past 24 h

Among the IMT group, no significant difference was found in average breathlessness for all paired time points, suggesting stable breathlessness. However, the score for average breathlessness at baseline (5.0±2.2) was significantly lower than T_1 (5.3±2.0), T_2 (5.5±2.4) and T_3 (6.1±1.8) in the no-IMT group, suggesting worsening breathlessness over time. For two independent group comparisons, the no-IMT group's average breathlessness was significantly (p=0.019) higher than the IMT group at T_3 (Fig. 3b)

Breathlessness now

The score for breathlessness 'now' at baseline was significantly lower compared to the data at T_1 (p=0.001), T_2 (p=0.009) and T_3 (p=0.002) in the IMT group. Similar results were found in the no-IMT group. No significant difference was found in all four independent group comparisons (Fig. 3c).

Distress experienced due to breathlessness

The mean breathlessness distress score at T_1 (4.7±2.1) was significantly lower (p=0.035) than the score at T_3 (5.4±2.6) in the no-IMT group, suggesting increasing distress in this

Table 1 Sample sociodemographic and clinical characteristics (N=46)

	N (%)
Gender	
Female	9 (19.6)
Male	37 (80.4)
Employment	
Full-time	2 (4.3)
Part-time	3 (6.5)
Retired	35 (76.1)
Unemployed/Unable to work due to illness	6 (13.1)
Education	
Secondary school	32 (69.6)
College	5 (10.9)
University	6 (13)
Did not answer	3 (6.5)
Treatment received	
Chemotherapy alone	16 (34.8))
Radiotherapy alone	2 (4.3)
Chemotherapy + radiotherapy	15 (32.6)
Surgery alone	2 (4.3)
Surgery + chemotherapy	6 (13)
Surgery + chemotherapy + radiotherapy	5 (10.9)
Type of lung cancer	
Small cell	8 (17.4)
Non-small cell	31 (67.4)
Mesothelioma	7 (15.2)
Stage	
Stage I	3 (6.5)
Stage II	8 (17.4)
Stage III	14 (30.4)
Stage IV	13 (28.3)
Unknown/no data	8 (17.4)
Use of steroids	13 (28.3)
Use of opioids	5 (10.9)
Use of oxygen	15 (32.6)

group. Significant difference was found in T_3 (p=0.018) between the two groups (mean=3.4±2.3 and 5.4±2.3 in IMT and no-IMT groups, respectively) (Fig. 3d).

Ability to cope with breathlessness

The mean scores for the IMT group at T_1 (7.6±1.7) and T_2 (7.5±1.9) were significantly higher (better) than those of the no-IMT group at T_1 (p=0.012, 6.7±1.6) and T_2 (p=0.023, 6.3±1.7), respectively (p<0.05).

Satisfaction with the management of breathlessness

The mean score in the IMT group at T_1 (7.5±2.0), T_2 (8.1±1.4) and T_3 (7.8±1.8) was significantly higher (better) than that of the no-IMT group at T_1 (p=0.02, 6.4±1.5), T_2 (p=0.001, 5.9±2.0) and T_3 (p=0.001, 5.4±2.2), respectively.

CRDQ

As this scale has not been used before with cancer patients, a reliability analysis took place showing good Cronbach alpha internal consistency reliabilities with this sample (alphas=0.89–0.92). No significant difference was found at each time point between the two groups related to CRDQ-dyspnoea. IMT CRDQ-fatigue scores at T_1 (8.2±2.1), T_2 (8.4±1.8) and T_3 (8.8±2.2) were significantly higher (better) than those in the no-IMT group with mean scores of 6.9±1.7, 7.0±1.8 and 6.8±1.9, respectively. CRDQ-mastery scores of the no-IMT group at T_1 (p=0.015), T_2 (p=0.028) and T_3 (p=0.036) were significantly lower than the IMT group. The scores of the no-IMT group at T_1 (p=0.024), T_2 (p=0.041) and T_3 (p=0.011) were significantly lower than the IMT group.

Anxiety and depression

In the IMT group, the mean score of the HADS-depression at T_2 was significantly lower than the scores measured at baseline (p=0.034) and T_1 (p=0.035) suggesting improvement within the group. In the no-IMT group, the HADS-depression score at T_3 was significantly higher from the scores measured at T_1 (p=0.026) and T_2 (p=0.035) suggesting worsening of depression within this group. There were significant differences in the depression score between the two groups (p=0.048) favouring the IMT group. No significant changes

Table 2 Spirometry results over time in the sample

Spirometry test		Baseline mean (SD)	T1 mean (SD)	T2 mean (SD)	T3 mean (SD)
Forced vital capacity (FVC)	IMT group	2.26 (0.69)	2.18 (0.77)	2.3 (0.7)	2.16 (0.74)
	Control group	2.57 (1.6)	2.1 (0.86)	2.04 (0.75)	1.95 (0.73)
Forced expiratory volume (FEV1)	IMT group	1.75 (0.67)	1.71 (0.66)	1.79 (0.63)	1.69 (0.63)
	Control group	1.64 (0.63)	1.62 (0.7)	1.53 (0.66)	1.43 (0.65)
Peak expiratory flow (PEF)	IMT group	231 (122)	246 (145)	231 (119)	233 (117)
	Control group	233 (136)	225 (136)	222 (143)	197 (125)

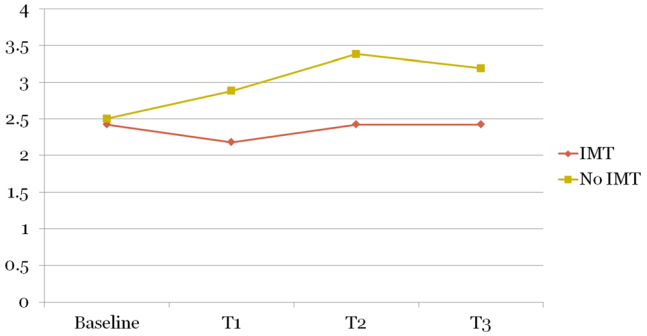

Fig. 2 mBorg score changes over the trial period (diff.=0.96 at T_2; 0.80 at T_3. Minimally important clinical difference=1)

were found in the HADS-anxiety score within the IMT group. In the no-IMT group, the HADS-anxiety score at T_3 was significantly higher than scores measured at earlier time points. There were significant differences in the anxiety score between the two groups (p=0.027) favouring the IMT group.

Study of area under the curve

Significant differences using area under the curve (AUC) were found with distress experienced due to breathlessness (p=0.03), the ability to cope with breathlessness (p=0.01) and satisfaction with breathlessness management (p=0.001). Moreover, significant differences were also found in three of the four domains of the CRQ, including fatigue (p=0.005), emotional functioning (p=0.011) and breathlessness mastery (p=0.015). Among the two domains in HADS, a significant difference was only found with regards to depression (p=0.028).

Safety

Half the patients in the IMT group complained of fatigue after the IMT training at baseline. One patient complained of chest muscle soreness after baseline training. Two patients

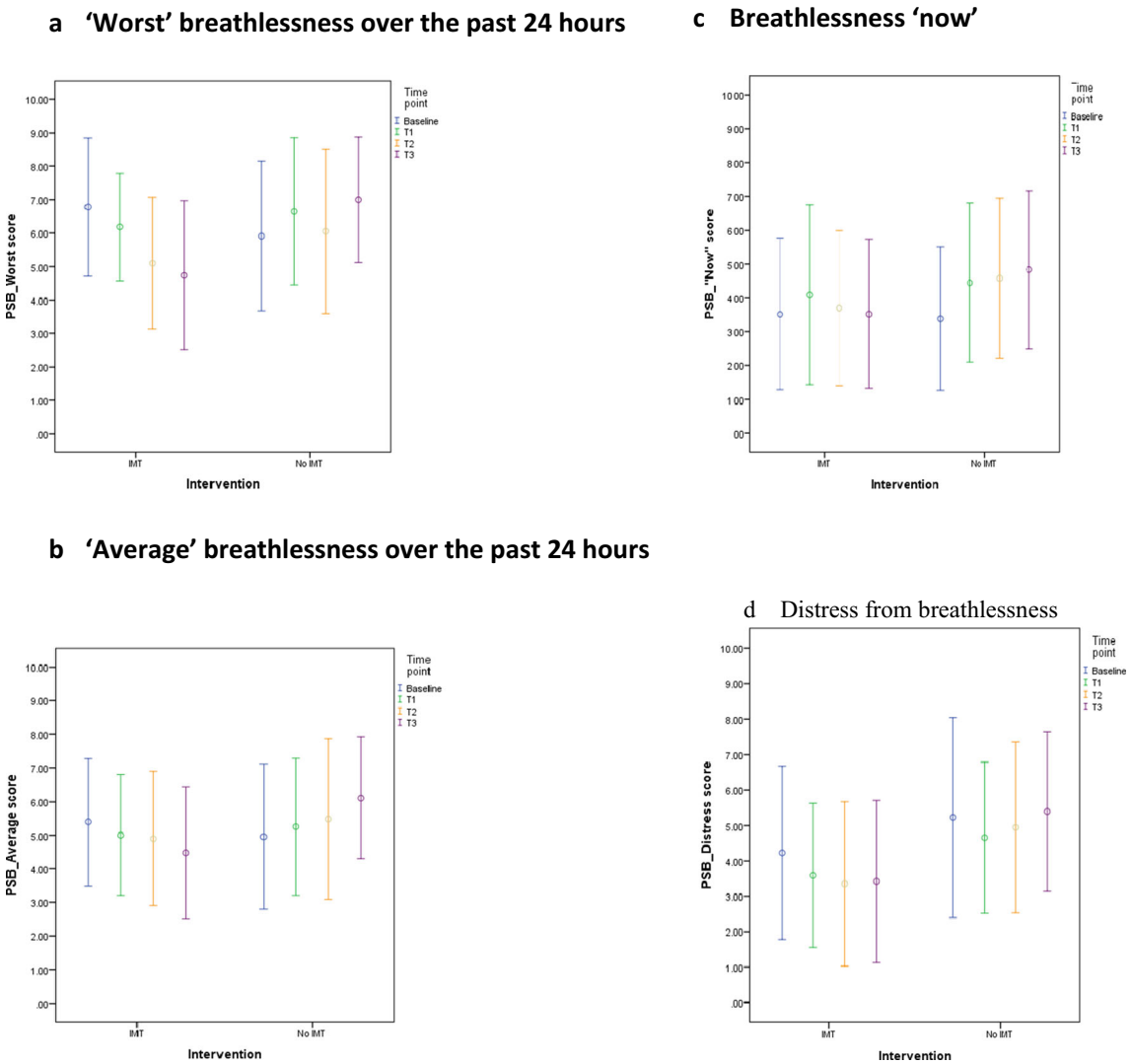

Fig. 3 Changes in breathlessness over the trial period. **a**. 'Worst' breathlessness over the past 24 h. **b**. 'Average' breathlessness over the past 24 h. **c**. Breathlessness 'now'. **d**. Distress from breathlessness

complained of signs of hypercapnea (headache; confusion) at T_1, and a further two after T_2. The symptoms of hypercapnea and some related to chest muscle soreness were related to patients doing the IMT exercises for more than the frequency and intensity they were asked to.

Discussion

This is the first trial to date assessing the effect of IMT in the management of breathlessness in patients with thoracic malignancies, when standard care alone is not adequate to resolve these symptoms. The results indicate that this intervention not only is feasible and acceptable for the patients with thoracic malignancies, but it is also linked with statistically and clinically important improvements in the outcome measurements. Positive effects on levels of breathlessness (mBorg scale, average breathlessness and 'worst' breathlessness over past 24 h, and distress from breathlessness) and anxiety were demonstrated after 3 months of treatment, alongside improvements in patients' ability to cope with breathlessness and satisfaction with the management of breathlessness. Changes in depression were evident from T_2 (8 weeks) while quality of life indicators (fatigue, breathlessness mastery and emotional function) improved significantly from the first month of treatment. These are important findings in the management of a complex and difficult symptom in a population with often progressive disease and worsening breathlessness. The findings suggest that the IMT group had more stable breathlessness experience compared to the control group in which breathlessness typically worsened.

Attrition was relatively low at 20 %, perhaps reflecting patients with relatively high performance status and clinically stable disease at study entry. The main barrier to recruitment was that many patients did not want or could not come to clinic for spirometry assessments and follow-up. In order to overcome this hurdle, the protocol was modified to provide home visits as an option, which helped with subsequent recruitment (all but one patients chose this option). The trial also under-recruited females, the reason of which is unclear. As can be deduced from the data of training frequency and duration, which differed from the planned one, patients probably found 30 min/day too much and were doing more frequent sessions for shorter times. In a future trial, this needs to be considered and incorporated into the protocol. Finally, as patients with stable disease are a minority in LC, it would be advisable for future studies to enrol patients in several centres with large patient populations (recruitment in this study was about two patients/month). Too intensive treatment (i.e. more than the recommended frequency and intensity), was linked with transient side effects, such as chest muscle aches. Hence, it is important that patients use IMT as recommended and build-up slowly their exercise regimen. The company producing the IMTs does not recommend IMT for current smokers; as the majority of LC patients are/were smokers, we did not follow this recommendation also after discussions with the medical team and observing that other COPD trials using IMTs had included smokers in their samples. However, we carefully monitored those patients for any problems, and no adverse events were observed.

Based on our findings, outcomes sensitive to change that could be used as primary outcomes in a larger trial are the mBorg (to which a fully powered trial needs 196 subjects at T_3) or 'worst' breathlessness (needing 194 patients at T_3), based on power calculations using the effect sizes of the analysed variables in the study. The mBorg score changes both at T_2 and T_3 were close to the minimally important clinical difference (MCID) of 1 suggested in the literature [25]. The same was true with the CRDQ, to which a score of around 0.5 per item is suggested as indicative of MCID [26] albeit not in a LC population, where even lower score changes may be important for the patients' lives.

Significant and relatively fast changes in areas such as ability to cope with breathlessness, mastery of breathlessness, satisfaction with breathlessness management, emotional functioning and fatigue may indicate that patients felt more in control of their symptom experience, and they may have been empowered to manage this situation more effectively, despite no obvious physiological changes in their FEV1 or FVC levels. Improvements in physiological indicators of lung capacity may be difficult to achieve in this group of patients, as the symptoms normally worsen as time goes by. It is questionable if such physiological parameters are useful indicators of the effectiveness of breathing exercises in patients with progressive illness. While we had significant missing data in the self-reports of oxygen, opioid and steroid use, leading us to the decision not to analyse this part of the data, it is acknowledged that these are important considerations in a future larger trial both in terms of medication use and as variables needing stratification in a future trial.

A larger well-powered trial is necessary before any concrete conclusions are derived about the usefulness of IMT in the management of breathlessness in patients with thoracic malignancies. This intervention is appropriate to a proportion of patients with thoracic malignancies with relatively stable disease, relatively higher performance status and life expectancy of >3 months. Patients with acute or severe breathlessness should be treated according to established protocols rather than IMT. There also needs to be commitment on behalf of the patients to carry out the training daily for at least 3 months, as clearly our data and much of the literature support this timing as an optimal timing to observe clinically important changes.

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Conflict of interest The authors have no conflicts of interest.

Disclosures None

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